The Center for Control, Dynamical Systems, and Computation
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Presents

Linear Iterative Strategies for Information Dissemination and Processing in Distributed Systems

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Abstract: A core requirement in distributed systems and networks is the ability to disseminate information from some or all of the nodes in the network to the other nodes. In this talk, we describe a linear iterative strategy for information dissemination, where each node repeatedly updates its value to be a weighted linear combination of its previous value and those of its neighbors. We show that this strategy can be compactly modeled as a linear dynamical system, and use control-theoretic tools (such as observability theory, structured system theory, and linear system theory) to characterize its capabilities. First, we show that in connected networks with time-invariant topologies, the linear iterative strategy allows every node to obtain the values of all other nodes after a finite number of iterations (or time-steps). The number of time-steps required is determined by the network topology and, in fact, may be minimal over all possible strategies for information dissemination. Next, we demonstrate the ability of the linear iterative strategy to handle a set of malicious (and possibly coordinated) nodes that update their values arbitrarily at each time-step. It has been established in the literature that when there are up to f malicious nodes, the network connectivity must be at least 2f+1 in order to accurately transmit information (with any protocol). Surprisingly, we show that the linear iterative strategy achieves this lower bound. Specifically, after running the linear iteration for a finite number of time-steps, each node in the network will have enough information (and a checking scheme) to correctly determine the values of the other nodes despite the actions of up to f malicious nodes. We thus establish linear iterative strategies as viable and effective means of disseminating information in networks.

About the Speaker: Shreyas Sundaram is a candidate for the Ph.D. degree in electrical engineering from the University of Illinois at Urbana-Champaign. He received the BASc. degree in computer engineering from the University of Waterloo in 2003, and the M.S. degree in electrical engineering from the University of Illinois at Urbana-Champaign in 2005. His research interests lie in the areas of secure and fault-tolerant control of large-scale distributed systems and networks, linear system and estimation theory, and the application of algebraic graph theory to system analysis. He received the M. E. Van Valkenburg Graduate Research Award and the Robert T. Chien Memorial Award from the ECE department at the University of Illinois at Urbana-Champaign, both for excellence in research. He was a finalist for the Best Student Paper Award at the 2007 and 2008 American Control Conferences.